

FIGURES

Figure 1-1.	Map of the Willamette River basin showing major tributaries and the locations of the thirteen USACE flood control projects.....	1-2
Figure 2-1.	Typical flood control operating strategy of Willamette Project facilities.	2-8
Figure 4-1.	General life stage periodicity chart for ESA listed fish species in the Willamette River basin, Oregon. Darker shade indicates heavier activity. Compiled from Nicholas (1978); USACE (1982); ODFW (1990a, b); Foster (1992); ODFW (1992); Cramer and Cramer (1994); Willis et al. (1995); Weitkamp et al. (1995); Busby et al. (1996); Buchanan et al. (1997); Myers et al. (1998); Unthank (1998); Taylor and Reasoner (1998); Scheerer (1999); Johnson et al. (1999); and Figures 6-2 through 6-4.....	4-2
Figure 4-2.	Life stage periodicity chart for ESA listed fish species in the Santiam River basin, Oregon. Darker shade indicates heavier activity. Compiled from OSGC (1963); ODFW (1990c); Buchanan et al. (1997); Myers et al. (1998); Unthank (1998); Taylor and Reasoner (1998); and Scheerer (1999).	4-3
Figure 4-3.	Life stage periodicity chart for ESA listed species in the McKenzie River basin, Oregon. Darker shade indicates heavier activity. Information is not available for winter steelhead. Compiled from ODFW (1990e); Humolka and Downey (1995); Willis et al. (1995); Buchanan et al. (1997); Unthank (1998); and Taylor and Reasoner (1998).....	4-4
Figure 4-4.	Life stage periodicity chart for ESA listed fish species in the Middle Fork Willamette River basin, Oregon. Darker shade indicates heavier activity. Compiled from ODFW (1990f); Buchanan et al. (1997); Unthank (1998); Taylor and Reasoner (1998); and Scheerer (1999).....	4-5
Figure 4-5.	Map of spring chinook habitat blocked in the Willamette River basin (from Cramer et al. 1996).....	4-13
Figure 4-6.	Number of Spring Chinook entering the Willamette River and catch in recreational fisheries of the lower Willamette and lower Clackamas rivers, 1946-1993 (from Cramer et al. 1996).....	4-15

Figure 4-7.	Scatter plot of the number of chinook smolts collected passing Leaburg Dam on the McKenzie River versus the number of adults in the parent run passing upstream of Leaburg Dam. Smolt production was indexed as the number of downstream migrants passing Leaburg from August in their first year of life through May in their second year. (from Cramer et al. 1996).....	4-18
Figure 4-8.	Adult spring chinook salmon passage over North Fork Dam on the Clackamas River in relation to Clackamas Hatchery escapement (from Cramer et al. 1996).	4-19
Figure 4-9.	Number of juvenile chinook salmon counted in the downstream migrant collection facility at North Fork Dam on the Clackamas River (from Cramer et al. 1996).	4-20
Figure 4-10.	Diagram showing most major destinations of the spring chinook run entering the Willamette River (from Cramer et al. 1996). Harvest rates in subbasins are approximate for 1975-1990. Run sizes above Willamette Falls are expressed as percentages of the counts at the falls.	4-21
Figure 4-11.	Cumulative percentage of a cohort harvested in all fisheries by the time it is ready to spawn (ocean harvest at each age and in-river harvest on the spawning run are included). Data are averages for the 1984-1989 broods from all Willamette River basin hatcheries. Harvested fish are distinguished by whether they were released initially as yearling (top) or as sub-yearling smolts (bottom) (from Cramer et al. 1996).	4-23
Figure 4-12.	Hatchery liberations of juvenile spring chinook salmon into subbasins of the Willamette River from the 1976-1993 broods (from Cramer et al. 1996).....	4-26
Figure 4-13.	Comparison of historical and recent timing of egg takes from spring chinook in the McKenzie River (from ODFW 1988).	4-28
Figure 4-14.	Estimated percentage of spring chinook spawning in the McKenzie River during 1992 by weeks (from Homolka and Downey 1995).	4-28
Figure 4-15.	Spring chinook smolt and fry migration at Leaburg Dam in the McKenzie River (from Willis et al. 1995).	4-31
Figure 4-16.	Passage time of juvenile chinook salmon passing Willamette Falls over the period 1992-1994 (from Willis et al. 1995).....	4-31
Figure 4-17.	Estimated number of native, hatchery, and wild winter steelhead passing Willamette Falls each year, 1971-1999; counts are from February 16 to May 15 each year (data from ODFW Clackamas, 1999).	4-45

Figure 4-18.	Percentage of the annual steelhead run that crossed Willamette Falls each week, averaged for 1984-1998. Introduced and natural runs are distinguished by February 15 as a cutoff date, and percentages are calculated relative to each run's total size (data from ODFW, Clackamas 1999).....	4-49
Figure 4-19.	Average monthly winter steelhead catch and percentage composed by non-native hatchery fish in the Molalla River, Oregon 1979-1986 (from Wevers et al. 1992a).....	4-49
Figure 4-20.	Weekly proportion of the adult coho run that passed North Fork Dam on the Clackamas River, Oregon, during 1957-1964, compared to 1988-1992 (from Cramer and Cramer 1994).....	4-62
Figure 4-21.	Estimated weekly landings in the Columbia River of CWT coho Clackamas wild stock, Sandy Hatchery stock, and Cowlitz Hatchery stock during 1988 and 1989; (from Willis et al. 1995).....	4-64
Figure 4-22.	Bull trout population survey data collected in Anderson Creek, Oregon, 1994-1999 (data from Taylor and Reasoner 1998; Unthank 1999).	4-80
Figure 5-1.	Monthly average flows at USGS Gage 14174000, Willamette River at Albany, Oregon (Moffatt et al. 1990).....	5-10
Figure 5-2.	Annual peak flows at USGS Gage 1191000, Willamette River at Salem, downstream of the 13 USACE Willamette River basin projects.	5-11
Figure 5-3.	Pre- and post dam flow duration curves based on mean daily flows at USGS Gage 14174000, Willamette River at Albany, Oregon (from Moffatt et al. 1990).....	5-12
Figure 5-4.	Willamette River channel simplification over time between 1854 and 1967. This 14-mile (23 km) section of river is between the McKenzie River confluence (RM 175) just downriver of Eugene to Harrisburg (RM 161) (from Sedell and Froggatt 1984).....	5-18
Figure 6-1.	Example of a flood control operation in the Middle Fork Willamette River. .	6-19
Figure 6-2.	Contribution of Blue River and South Fork McKenzie River to flow in the mainstem McKenzie River before and after construction (USACE 1995a). ..	6-24
Figure 6-3.	Comparison of mean daily water temperatures (10-day intervals) measured in the North Santiam River above Detroit Lake (USGS Station 14178000) and below Big Cliff Dam, Oregon (USGS Station 14181500); 1968-1985 (USACE 1988).	6-37

Figure 6-4.	Comparison of mean daily water temperatures (10-day intervals) measured in Quartzville Creek (USGS Station 14185900; 1968-1985) above Green Peter Reservoir, and in the South Santiam River (USGS Station 14186700; 1968-1972) below Foster Dam, Oregon (USACE 1988).	6-39
Figure 6-5.	Comparison of mean daily water temperatures (10-day intervals) measured in the Middle Santiam River near its mouth (USGS Station 14186500 before construction of Foster Dam (1954-1965), and in the South Santiam River below Foster Dam, Oregon (USGS Station 14186700) after its construction (USACE 1988).....	6-40
Figure 6-6.	Comparison of mean daily water temperatures (10-day intervals) measured in the South Santiam River below Foster Dam, near Waterloo, Oregon (USGS Station 14187500): 1964-1966 (before Foster/Green Peter) and 1968-1985 (after Foster/Green Peter) (USACE 1988).	6-41
Figure 6-7.	Comparison of mean daily water temperatures (10-day intervals) measured in the Santiam River near Jefferson, Oregon (USGS Station 14187500): 1964-1966 (before Foster/Green Peter) and 1968-1985 (after Foster/Green Peter) (USACE 1988).	6-42
Figure 6-8.	Representative water temperature profiles measured in June at Blue River and Cougar lakes (USACE 1995a).	6-43
Figure 6-9.	Thermal conditions measured in 1984 in Blue River Reservoir (USACE 1995a).	6-44
Figure 6-10.	Representative thermal conditions measured in 1984 in Cougar Reservoir (USACE 1995a).	6-45
Figure 6-11.	Average daily water temperatures measured at Hills Creek Reservoir, Oregon, 1960-1987, and general chinook salmon life stage periodicities (USACE 1997).	6-52
Figure 6-12.	Average daily water temperatures measured in the Middle Fork Willamette River, Oregon, thirteen miles below Hills Creek Dam, before (1950-1961) and after (1962-1987) its construction, and general chinook salmon life stage periodicities (USACE 1997).	6-53
Figure 6-13.	Monthly (top) and daily (bottom) average water temperatures in the Middle Fork Willamette River, Oregon, measured above Lookout Point Reservoir and below Dexter Dam, before (top) and after (bottom) construction of Hills Creek Dam (USACE 1997). General chinook salmon life stage periodicities are also indicated.	6-54

TABLES

Table 1-1.	Listed, proposed, and candidate populations (Federal Endangered Species Act) of fish species in the Willamette River basin, Oregon.	1-9
Table 1-2.	Listed and proposed plant and plant species (Federal Endangered Species Act) in the Willamette River basin, Oregon.	1-10
Table 1-3.	Fisheries enhancement and mitigation projects funded by BPA in the Willamette River basin above Willamette Falls. These projects were funded under the Northwest Power Planning Council’s Columbia River Basin Fish and Wildlife Program (NPPC 1994) (from P. Smith, BPA).....	1-13
Table 2-1.	Operational data for Willamette River basin projects.	2-3
Table 2-2.	Principal downstream flood control points for Willamette River basin projects.	2-7
Table 2-3.	Downstream control points on the Middle Fork and mainstem Willamette River.	2-8
Table 2-4.	Maximum evacuation releases (in cfs) for normal flood control regulation, as measured at downstream control points.	2-10
Table 2-5.	Storage volumes presently under contract for irrigation use.	2-13
Table 2-6.	Minimum flow requirements at Albany and Salem (in cfs)	2-17
Table 2-7.	Volume of water used to meet minimum flow requirements (acre-feet) at Albany and Salem.....	2-17
Table 2-8.	Average monthly power generation (in megawatts), Willamette River basin projects (1983-1995).	2-19
Table 2-9.	Priorities of Willamette River basin storage projects.	2-22
Table 2-10.	Land use classifications for USACE Willamette Basin project lands.	2-24
Table 2-11.	List of bank protection structures associated directly or indirectly with USACE activities in the Willamette River basin.	2-71
Table 2-12.	Willamette Project activities related to emergency assistance under PL 84-99.	2-81

Table 4-1.	Pre-dam and current distribution of spring chinook salmon in the Willamette River basin based on a review of Mattson (1948) and ODFW subbasin fish management plans (Howell et al. 1988; Connolly et al. 1992a, 1992b; Murtagh et al. 1992a, 1992b; Rien et al. 1992; Wevers et al. 1992a, 1992b).	4-9
Table 4-2.	Pre-dam (minimum estimates of natural production) and current (natural and hatchery) run sizes of spring chinook salmon in major production areas of the Willamette River basin. Note that pre-dam estimates are not representative of pre-European settlement run sizes (from Willis et al. 1995).	4-16
Table 4-3.	Estimated return of spring chinook to the McKenzie River and escapement above Leaburg Dam (ODFW data, Springfield).	4-17
Table 4-4.	Willamette River basin spring chinook salmon production facilities (from Willis et al. 1995).	4-25
Table 4-5.	Percentage by age class of returning spring chinook salmon caught in the lower Willamette River from 1946 to 1950 (Mattson 1948) and from 1983 to 1993, and for spring chinook salmon returning to the Clackamas River from 1977 to 1988 (from Bennett 1994).	4-32
Table 4-6.	Spawning areas of Willamette winter steelhead in the Willamette River basin, Oregon, after Willamette Project Construction (Fulton 1970).	4-43
Table 4-7	Estimated indices of spawner abundance for five winter steelhead populations in the Willamette River basin, Oregon above Willamette Falls; spawner abundance expressed as total fish for the upper South Santiam population and spawners per stream mile for all other populations (data from Chilcote 1998).	4-53
Table 4-8.	Ten year means of estimated maximum inriver, ocean, and total proportion harvested for lower Columbia River coho, 1950 - 1989 (from ODFW 1990g).	4-62
Table 4-9.	Reported historic distribution of bull trout in the Willamette River basin.	4-75
Table 4-10.	Summary of Bull Trout Populations - McKenzie River, Oregon (Taylor and Reasoner 1998; Unthank 1998, 1999).	4-79
Table 5-1.	Current or recent distribution of fish species in major rivers of the Willamette Project, Oregon (modified from Altman et al. 1997).	5-4
Table 5-2.	Distribution of irrigated land, type of irrigation water, and total acres of irrigated lands in four regions of the Willamette River basin, Oregon, in 1990.	5-13

Table 5-3.	Generalized impacts of reduced peak flows and interception of bedload sediments on gravel bed river channel morphology.....	5-15
Table 5-4.	Estimates of smolt production capacity for natural production of spring chinook salmon in the Willamette system (ODFW 1990a, 1990c).....	5-21
Table 5-5.	Estimate of smolt production capacity for natural production of winter steelhead in the Willamette system (ODFW 1990a).	5-21
Table 5-6.	Major streams of the North Santiam River subbasin, Oregon, with fish production potential (data compiled from Mattson 1948; Willis et al. 1960; Fulton 1968; Fulton 1970; McIntosh et al. 1995; Buchanan et al. 1997; USFWS 1998a).....	5-28
Table 5-7.	Major streams of the South Santiam River subbasin with fish production potential (data compiled from Mattson 1948; Willis et al. 1960; Fulton 1968; Fulton 1970; McIntosh et al. 1995; Buchanan et al. 1997; USFWS 1998a).	5-38
Table 5-8.	Major streams of the McKenzie River subbasin, Oregon with fish production potential (data compiled from Mattson 1948; Willis et al. 1960; Fulton 1968; Fulton 1970; USFS 1994; McIntosh et al. 1995; Buchanan et al. 1997; USFWS 1998a).....	5-46
Table 5-9.	Major streams of the Middle Fork Willamette River subbasin with fish production potential (data compiled from Mattson 1948; Willis et al. 1960; Hutchison et al. 1966a; Fulton 1968; Fulton 1970; McIntosh et al. 1995; Buchanan et al. 1997; USFWS 1998a).....	5-58
Table 5-10.	Spring chinook smolt production potential in the Middle Fork Willamette River subbasin (based on an assumed juvenile density of 0.2 fish/m ² of habitat).	5-63
Table 5-11.	Major streams of the Coast Fork Willamette River subbasin with fish production potential (data compiled from USFWS 1948; Willis et al. 1960; Hutchison et al. 1966a; Fulton 1968; Fulton 1970; McIntosh et al. 1995; Buchanan et al. 1997; USFWS 1998a).....	5-67
Table 5-12.	Major streams of the Long Tom River basin with fish production potential (data compiled from Mattson 1948; Willis et al. 1960; Fulton 1968; Fulton 1970; McIntosh et al. 1995; Buchanan et al. 1997; USFWS 1998a).	5-73
Table 6-1.	Minimum instream flow requirements downstream of Willamette Project dams, Oregon (Source: WRIS files, OWRD 1999).....	6-6

Table 6-2.	Flows recommended for good upstream passage of salmon and steelhead for rivers that are regulated by Willamette Project dams, Oregon (USACE 1982).....	6-8
Table 6-3.	Minimum spawning flows recommended below each reservoir for rivers that are regulated by Willamette Project dams, Oregon (USACE 1982).	6-9
Table 6-4.	Minimum incubation flows recommended below each reservoir for rivers that are regulated by Willamette Project dams, Oregon (USACE 1982).	6-10
Table 6-5.	Minimum flows recommended for salmonid rearing for rivers that are regulated by Willamette Project dams, Oregon (USACE 1982).	6-11
Table 6-6.	Maximum flow recommended during spawning to keep redds in water during incubation for rivers that are regulated by Willamette Project dams, Oregon (USACE 1982).	6-12
Table 6-7.	Selected monthly flow duration statistics measured at USGS gages located below Willamette Project dams, Oregon (Data from Moffatt et al. 1990).....	6-13
Table 6-8.	Estimated change in mean water velocity after dam construction in the Willamette River basin, calculated for average monthly flows.....	6-16
Table 6-9.	Water temperature criteria for listed and candidate fish species potentially influenced by water temperature effects of the Willamette Project (Compiled from: Bell 1991; ODEQ 1995; McCullough 1995; Buchanan and Gregory 1997; Scheerer 1999). Key to abbreviations in table: F=Fall run, Sp=Spring run, Su=Summer run; M=Migration; Di=Disease; R=Rearing; H=Holding.	6-28
Table 6-10.	Relevant State of Oregon water quality criteria for the Willamette River basin.....	6-33
Table 6-11.	Ranges of target water temperatures (°C) in the McKenzie River basin for the Willamette temperature control project (USACE 1995a).	6-47
Table 6-12.	Current mean daily temperatures in the South Fork McKenzie River below Cougar Dam, and in the mainstem McKenzie River downstream, during months important to the different life history stages of bull trout that might use those reaches (USACE 1995a).	6-49
Table 6-13.	Estimated spawning habitat quantities above and below Willamette Project dams, Oregon (Craig and Townsend 1946).....	6-67
Table 6-14.	Approximate miles of river habitat inundated by Willamette Project reservoirs, Oregon (USACE project data).	6-68

Table 6-15	Angling and steelhead smolt catch in Foster Reservoir, Oregon, from 16 April to 5 June 1983 (from USACE 1993).....	6-102
Table 6-16.	Estimated angler effort and catch in the McKenzie River, Oregon, 1983 trout season (from Hutchison and Hooton 1990).	6-105
Table 6-17.	Summary matrix of the most likely current effects of the Willamette Project on the <u>Upper Willamette Chinook Salmon ESU</u> , with respect to baseline at the time of listing under the federal ESA (LBA = Likely to Beneficially Affect; LAA = Likely to Adversely Affect; PAA = Potential to Adversely Affect, but unconfirmed).	6-121
Table 6-18.	Summary matrix of the most likely current effects of the Willamette Project on the <u>Upper Willamette Steelhead ESU</u> , with respect to baseline at the time of listing under the federal ESA (LBA = Likely to Beneficially Affect; LAA = Likely to Adversely Affect; PAA = Potential to Adversely Affect, but unconfirmed).	6-123
Table 6-19.	Summary matrix of the most likely current effects of the Willamette Project on the <u>Columbia River Bull Trout DPS</u> , with respect to baseline at the time of listing under the federal ESA (LBA = Likely to Beneficially Affect; LAA = Likely to Adversely Affect; PAA = Potential to Adversely Affect, but unconfirmed).	6-125
Table 6-20.	Summary of effects to listed and proposed endangered and threatened wildlife and plants.	6-127